Photoelectrochemical Water Splitting for Hydrogen Production Using Multiple Bandgap Combination of Thin Film Photovoltaic-Cell and Photocatalyst

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Planned Completion = September 2006

Outline

- Research Goals and Objectives
- Relevance to Current State-of-the-Art
- Schedule and Deliverables
- Anticipated Technology End Use
- Accomplishments and Results
- Future Plans

Research Goals and Objectives

- To develop efficient and economic PEC cells for production of highly pure hydrogen and oxygen in the requisite proportion by water splitting using multiple bandgap combination of thin-film photovoltaic-cell and photocatalyst.

Current State-of-the-Art

- Presently efficient photoelectrochemical (PEC) cells are too expensive (III-V) while cheaper cells are not efficient (a-Si:H).
- Moreover, the PV cells are in contact with the electrolyte - leading to corrosion problem
- Such PEC setup may have limited stability.

Relevance to Current State-of-the-Art

- The PEC cells developed at FSEC PV Materials Lab will be efficient and economical
- In the FSEC PEC setup, the PV cells are not in contact with the electrolyte – problem of corrosion is minimized.
- RuS_2 and $Ru_{0.99}Fe_{0.01}S_2$ anodes which are in contact with the electrolyte are highly stable, even more stable than RuO_2 and therefore, the PEC setup will last long.

Schedule and Deliverables

- **Schedule**
  - Nov 2005 – Mar 2006: Develop CIGS2/CdS thin film PV cells on ITO/MoS_2 and CdS/CdTe cells on ZnTe:Cu transparent conducting back layers.
  - Apr 2006 – Sep 2006: Develop $Ru_{0.99}Fe_{0.01}S_2$ photoanodes and PEC setup to achieve PEC efficiency of >8%.

- **Deliverables**
  - 1st Six Months: Six Monthly Report (March 2006)
  - 2nd Six Months: Annual Report (September 2006)

Anticipated Technology End Use

- Highly pure hydrogen and oxygen can be obtained in requisite amounts
- Can be useful in space shuttle and space missions.
- Can be useful in the launch facility.
- Can be used in fuel cells and automobile applications.

Accomplishments and Results

- FSEC PV Materials Lab has been working on PEC water splitting for the last 6 years.
- PEC efficiency in 2002 – 1.99% with CIGS2/CdS thin film PV cell as cathode and RuO_2 anode.
- New PEC setup with multiple bandgap tandem of PV cells, photoanode for oxygen generation and platinum for hydrogen generation was designed and developed.

Accomplishments and Results

- Platinum, RuO_2, RuS_2 and $Ru_{0.99}Fe_{0.01}S_2$ anodes were developed and tested for efficient oxygen generation.
- PEC efficiency 2003 – 4.29% (Two CIGS2/CdS thin film PV cells in series, RuO_2 anode and platinum cathode)
- PEC efficiency 2004 – 5.25% (two CdTe thin film PV cells, RuS_2 anode and platinum cathode)

Accomplishments and Results contd.

- Electrolyte concentration was increased to reduce the series resistance.
- PEC efficiency May 2005 – 6.76% (two CdTe thin film PV cells, RuS_2 anode and platinum cathode)
- PEC efficiency October 2005 - >7% (two CIGS2/CdS PV cells, RuS_2 anode and platinum cathode)

Future Plans

- Develop PV cell on transparent conducting back layers.
  - CdS/CdTe superstrate PV cells on ZnTe:Cu back contact layer and CIGS2/CdS thin film PV cells on ITO/MoS_2 back contact.
- Make infrared photons not absorbed at the PV cell incident on $Ru_{0.99}Fe_{0.01}S_2$ photoanode to reduce overpotential required for oxygen evolution.

Future Plans

- With the facilities developed along with the knowledge and experience gained from NASA Hydrogen project, it is expected to achieve PEC efficiency >8% by September 2006.
- This will be an important milestone for practical applications.

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